



June 28, 2006  
VS Release #06-27  
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## Perseverance pays off for Micro-Meteoroid Impact Experiment program

*Space Vehicles Directorate research project focused on detecting and characterizing the damaging impact of tiny hypervelocity particles on satellites*

Reproducing on the ground comet-origin particles traveling between 44,739 to 134,216 miles per hour striking a satellite and creating resultant radio wave emissions, which could hinder communication to the warfighter and cause damage to the structure, proved to be a daunting challenge for scientists serving with the Air Force Research Laboratory's Space Vehicles Directorate, Kirtland Air Force Base, N.M., but persistence and a strategy change made the impossible possible.

During the second round of trials conducted in May 2006, directorate researchers, partnering again with Sandia National Laboratories, also located at the New Mexico installation, employed the Dept. of Energy organization's Shock Thermodynamics Applied Research (STAR) facility's light gas gun to fire a projectile at 43,000 miles per hour into an apparatus covered with multi-layer insulation and the high-velocity blast's impact produced radio wave emissions.

"The micro-meteoroid impact experiment was going nowhere until we decided to shoot the multi-layer insulation, which serves as the thermal blanket covering a spacecraft and is composed primarily of plastics," said Dr. Michael Starks, bench scientist and electronics engineer, Space Vehicles Directorate's Battlespace Environment Division, Hanscom AFB, Mass. "This is the type of material that is hit by micro-meteoroids in space so it made sense to apply it for the trial. The projectile hit the target at 18 kilometers per second (43,000 miles per hour) and we saw fairly strong radio frequency emissions right at the moment of impact."

Sparked from an idea discussed by a visiting Italian scientist in 2001, the micro-meteoroid impact experiment team took existing information on damaging milligram-sized pieces of carbon and other materials hitting spacecraft and focused on determining whether these same particles produce plasma which could ultimately cause communication interference. Currently, micro-meteoroid detection on a satellite involves a small sheet of film, which creates a monitored electrical signal, but due to size constraints, impact coverage for the majority of the structure remains limited.

"If a satellite becomes inoperable today, the only way we know if it was a micro-meteoroid is through a diagnosis of exclusion," said Dr. Starks. "If no other reason is found, then maybe it got hit. Because of our dependency on space, it is critical to understand the effects of high-velocity impacts so we can operate effectively in the space environment."

To replicate a micro-meteoroid impact on a spacecraft, experiment personnel partnered with Sandia National Laboratories' Explosives Technology Group, which provided the hypervelocity launcher capable of shooting small titanium plates at speeds of 32,000 plus miles per hour. For two weeks in May 2004, five shots penetrated an apparatus equipped with low and high frequency antennae, as well as a tungsten, and for the last four

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sessions, an indium target four inches wide. Following the trials, researchers found plenty of radio signals produced by the projectile itself, but none originating from the impact. As a result of the failed tests, the experiment group headed back to the drawing board.

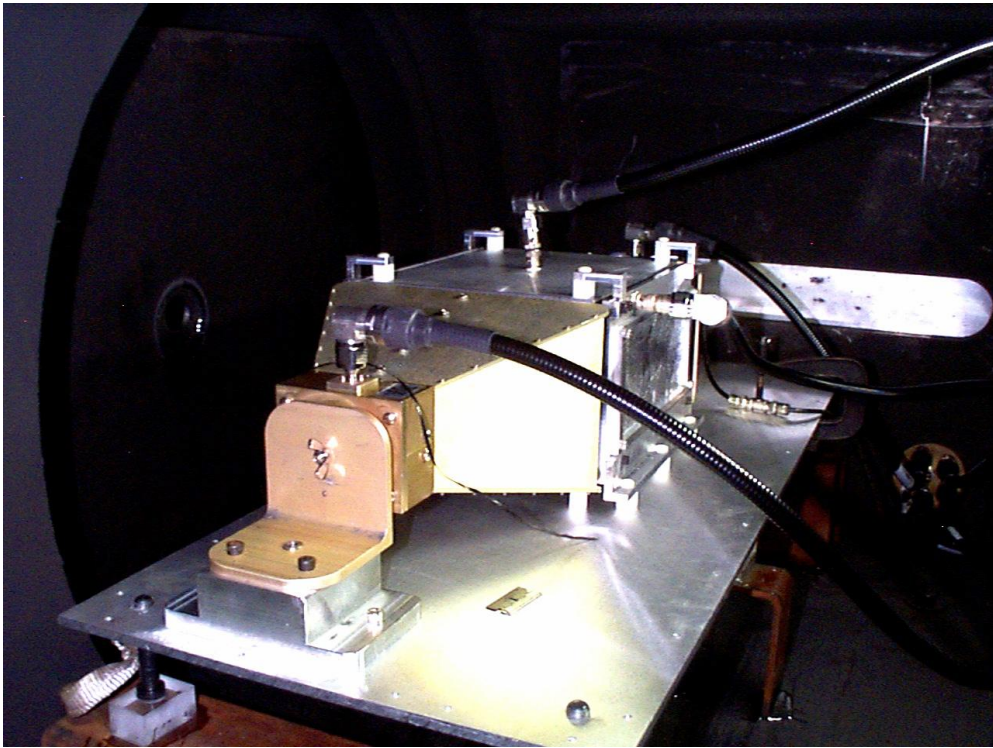
“At this point, the team decided to step back and take a look at trying something else,” said the experiment leader. “In addition, we did not think we could get rid of the confusing signals coming from the launcher (gun), but we were determined to give it another try.”

During the two-year hiatus from the initial evaluation to the next set of trials in May 2006, Sandia National Laboratories’ light gas gun established new speed records by firing projectiles over 43,000 miles per hour, and the experiment team investigated employing different pellet made of copper, iron, carbon and other materials rather than titanium. Disappointingly, the first two of a total of five scheduled shots fired in round two revealed no radio wave emissions in the strike zone consisting of indium for the initial evaluation and aluminum for the second assessment. Desperate times called for innovative thinking. Dr. Starks and his group decided for the final three tries to use multi-layer insulation and their resolve paid off. Each successive firing produced radio wave emissions occurring at the insulated impact area.

“We were not going to give up. We intended to get all of the shots in during the second trial,” said Dr. Starks. “The keys to success were Sandia National Laboratories’ gun attaining faster speeds and shooting at the multi-layer insulation.”

Following their recent success and planned follow-up tests, the project team hopes to eventually apply the experimental results to an orbit of flight instruments to enhance current space situational awareness technology.

“The micro-meteoroid impact experiment is ultimately about protecting our critical military and civilian space assets,” Dr. Starks said. “As spacecraft become more indispensable, we have to protect them from damage caused by particle impacts.”



Positioned in the Sandia National Laboratories' hypervelocity launcher, the micro-meteoroid impact experiment apparatus awaits a shot from the light gas gun during the initial trials conducted in May 2004. (U.S. Air Force photo)



Following an evaluation in May 2004 at Sandia National Laboratories' hypervelocity launcher, the micro-meteoroid impact experiment apparatus exhibits the after effects of being shot with a projectile traveling at speeds in excess of 40,000 miles per hour. (U.S. Air Force photo)